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Serial No. 09/883,366
Response to Office Action dated March 25, 2004

Remarks

Reconsideration and allowance of the subject patent application are respectfully requested.

Applicants' representative wishes to thank Examiners Im and Lee for the courtesy extended during the interview on June 30, 2004. The substance of this interview is included the remarks presented below.

Claims 1-10 and 17-34 were rejected under 35 U.S.C. Section 112, second paragraph, as allegedly being indefinite. Based on the discussions at the interview, claims 1, 17 and 25 have been amended to describe that the metal layer is formed to completely cover a bottom surface, but not to completely cover side surfaces, of an opening section (or opening) of an insulating layer. This language is consistent with the example embodiments shown in the Figures of the subject patent application and withdrawal of the Section 112, second paragraph, rejection of claims 1-10 and 17-34 is respectfully requested.

The illustrative example embodiments described in the present application show a semiconductor device in which a metal layer is provided in an opening formed in an insulating layer that exposes a conductor. The metal layer covers the exposed conductor, but does not completely cover the side surfaces of the opening, and is provided between the conductor and a protrudent electrode that is made of Sn or a metal having Sn as its main component. Among other things, these illustrative example embodiments can prevent deterioration of connection reliability due to gap formation in the vicinity of the protrudent electrode. Good connection reliability of the protrudent electrode may be provided by using Sn or a metal having Sn as its main component, which have good wetting properties. By providing the metal layer so as to cover the upper surface portion of the conductor exposed by the opening, but not, for example, to completely cover side surfaces of the opening, no gap is formed between the insulating layer and the protrudent electrode, even if metal from the metal layer diffuses into the protrudent electrode. Thus, it is possible to prevent the deterioration in reliability due to water condensation in the gap.

Claims 1-9, 29 and 30 were rejected under 35 U.S.C. Section 103(a) as allegedly being obvious over Akram (U.S. Patent No. 5,736,456) in view of Okada *et al.* (U.S. Patent No.

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6,111,317) and Andricacos *et al.* (U.S. Patent No. 5,937,320). As discussed at the interview and as set forth in the remarks below, Applicants traverse this rejection.

Akram discloses a method of forming conductive bumps on a die for flip chip applications. Akram shows in Figures 2-4 metal layers 68, 70, 72 that completely cover both the bottom and side surfaces of the opening formed in insulating layer 56 to expose conductive trace 54. Similar arrangements are shown in Figures 1 and 8. Thus, Akram is clearly deficient with respect to the language in claim 1 calling for a metal layer that completely covers a bottom surface, but does not completely cover side surfaces, of the opening section on a main conductor layer. The office action purports that Okada *et al.* remedies this deficiency of Akram. Specifically, the office action contends that Figure 5 of Okada *et al.* shows “a bump contacting the top of metal layers (16-1, 16-2) that are formed on the top of conductive layer (14).”

Contrary to the assertions in the office action, there is nothing in Okada *et al.* that would have suggested modifying layers 68, 70, 72 of Akram to completely cover the bottom surface of the opening in insulating layer 56, but not to completely cover the side surfaces thereof. None of the metal layers 14, 16-1, 16-2 in Okada *et al.* is formed on the bottom surface of the opening in insulating layer 15. Indeed, metal layer 16-2 is the bottom surface of the opening, not a layer that covers such a surface. With this in mind, the combination of Okada *et al.* and Akram might, for example, result in forming the bump electrode of Arkam directly on conductive trace 54 just as the bump electrode of Okada *et al.* is formed directly on metal layer 16-2. However, Okada *et al.* simply provides no teaching or suggestion whatsoever with respect to any modifications of layer 68, 70, 72 of Akram.

Andricacos *et al.* is cited simply for its teaching at col. 1, lines 62-64 of using Sn as a low-melting solder and the combination of this reference with Akram and Okada *et al.*, even if proper, would not have resulted in the subject matter of claim 1.

Claims 2-9, 29 and 30 depend from claim 1 and likewise would not have been rendered obvious by the proposed combination of Akram, Okada *et al.* and Andricacos *et al.*. These dependent claims also recite additional patentable features. By way of example, claim 9 calls for the barrier metal layer to cover side surfaces of the main conductor layer. An illustrative example of this arrangement is shown in Figure 6 of the subject patent application. The office

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action references col. 6, lines 45-57 as allegedly showing this feature. However, no such feature is shown in the drawings of Okada *et al.* and the referenced portion of Okada *et al.* merely describes that barrier metal layer 16 and conductive layer 14 can be patterned in an etching step using a single mask. The reference to "side-etching" is in connection with metal pad 18 and has nothing to do with forming a metal layer to cover the side surfaces of a main conductor.

Claim 10 was rejected under 35 U.S.C. Section 103(a) as allegedly being obvious over the proposed combination of Akram, Okada *et al.* and Andricacos *et al.*, in further view of Stamper *et al.* (U.S. Patent No. 6,362,531). Stamper *et al.* does not, for example, remedy the deficiencies of the proposed Akram-Okada *et al.*-Andricacos *et al.* combination with respect to claim 1. Thus, claim 10, which depends from claim 1, would not have been rendered obvious by the proposed four-way combination of Akram, Okada *et al.*, Andricacos *et al.* and Stamper *et al.*

Claims 17, 22-24, 31 and 32 were rejected under 35 U.S.C. Section 103(a) as allegedly being "obvious" over Akram in view of Rates (U.S. Patent No. 5,736,456) and Andricacos. With respect to independent claim 17, Akram at least fails to disclose the claimed metal layer that completely covers the upper surface portion of a wiring layer exposed by an opening in an insulating layer, but does not completely cover the side surfaces of the opening. The office action purports to remedy this deficiency using Rates. Rates purports to increase the reliability of a die by reducing the potential for intermetallic reaction (purple plague) that typically takes place between an aluminum bond pad and a gold wire. Rates also provides a conductive material such as a gold bump on an aluminum bond pad for providing a contact of similar material to a lead used in the testing and burn-in process. Figure 1 of Rates, referenced in the office action, is a cross-sectional view of a die bond pad having a field metals layer 16 affixed between a gold bump 18 and an aluminum bond pad. The field metals layer 16 is composed of a first field metal layer 20 of titanium and tungsten (Ti/W) and a second field metal layer 22 of gold, thereby preventing an intermetallic reaction that reduces die reliability. Among other things, Rates provides no motivation to modify Akram. Indeed, the assertions in the office action regarding better defining bond pad windows and sealing pin holes are attributed in the Rates specification to providing a second passivation layer 26, not to any characteristics of metal layers 16, 22. Thus, there would have been no motivation to modify the characteristics of the metal layer in

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Akram based on Rates. Andricacos *et al.* is again cited for its disclosure of using Sn as a low-melting solder and the combination of this reference with Akram and Rates (even if proper) would not have resulted in the subject matter of claim 17.

Claims 22-24, 31 and 32 depend from claim 17 and likewise would not have been rendered obvious by the proposed combination of Akram, Rates and Andricacos *et al.* These dependent claims also recite additional patentable features.

Claims 18-21 (which depend from claim 17) were rejected under 35 U.S.C. Section 103(a) as allegedly being "obvious" over the proposed combination of Akram, Rates and Andricacos *et al.*, in further view of Greer (U.S. Patent No. 6,451,681). The office action alleges that Greer teaches a multi-layered conductive layer (122, 124, 200, 202). However, even assuming the barrier layer 122 and the adhesion layer 200 of Greer are alleged to correspond to the first and second metal layer of claim 18, this purported "conductive layer" of Greer is not connected to an electrode pad formed on a semiconductor substrate as claimed. As such, Greer would not have provided any teaching or suggestion to modify the conductive layer of Akram as proposed. In any event, Greer does not remedy the deficiencies of the proposed Akram-Rates-Andricacos *et al.* combination with respect to claim 17 and thus even if the multi-layer conductor identified in the office action could somehow be added to the combination, the subject matter of claims 18-21 (which depend from claim 17) would not have resulted.

Claims 25-28, 33 and 34 were rejected under 35 U.S.C. Section 103(a) as allegedly being "obvious" over Akram in view of Rates and Greer. The office action relies on Rates to remedy the deficiencies of Akram with respect to the claimed metal layer and further relies on Greer to remedy the deficiencies of Akram and Rates with respect to a wiring layer that comprises first, second and third metal layers. In particular, the office action alleges that layers 304, 306 and 308 correspond to the claimed first, second and third metal layers of the claimed wiring layer. For reasons similar to those set forth above with respect to the rejection of claim 17, Akram and Rates are not properly combinable to provide a metal layer as claimed in claim 17. In addition, Applicants do not believe the layers identified in Greer in the office action would have provided motivation to incorporate such layers into a device resulting from the proposed combination of Akram and Rates.

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Claims 26-28, 33 and 34 depend from claim 25 and likewise would not have been rendered obvious by the proposed combination of Akram, Rates and Greer. These dependent claims also recite additional patentable features.

New claim 35 has been added. The subject matter of this new claim is fully supported by the original disclosure and no new matter is added. This claim describes, among other things, that the metal layer has lateral dimensions defined by the size of the opening section. This feature is based on the discussions at the interview with Examiners Im and Lee. The subject matter of this claims is believed to clearly distinguish over the various combinations of documents proposed in the office action.

Applicants submit that the pending claims are in condition for allowance, and action to that end is earnestly solicited.

If any issues remain to be resolved, the Examiner is urged to contact the attorney for Applicants at the telephone number listed below.

Respectfully submitted,

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